Preposterous* Precipitation – A Practitioner’s Perspective

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Extreme Precipitation Workshop
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* “beyond reason & convention” thesaurus category
Where are the Practitioners?

- Agriculture
- Stormwater *
- Hydrology / Hydraulics *
- Water Supply
- Sewer Districts
- Watershed Management
- Ecohydrology *
- **Transportation**

*Apologies to Prof. Frink*
Extremes - A Matter of Scale

• Space
  – $10^{-3}$ mi$^2$ to $10^{3+}$ mi$^2$

• Time
  – 5 min to 72+ hrs
  – Weeks to months to years!

• Time & Space often go hand in hand
  – larger watersheds imply longer time scales

• Identified Needs also dictate scales
  – Ag & Water Supply: seasonal, annual, multi-year
  – Hydraulic structures: event-based – minutes to hours
Not All Extremes are Big

- Droughts

- Flood
  Carrabassett, ME Rt 27
What Kinds of Data do We Use?

- Event-Based Design of Hydraulic Structures
  - Depth-duration-frequency
  - Intensity-duration-frequency

- Continuous Time Series
  - Analysis and design of systems
    - Water supply
    - Stormwater
    - Sewer
  - Extremes take care of themselves
Extreme Precipitation

- A HUGE Subject
- Bigger than a 6-hr workshop
- Time now to limit my comments
  - Hydrologic design in transportation
    - Hydraulic Structures
    - Civil / site design
    - Stormwater
  - Northeast US
  - Rural state

Percent increase from 1958 to 2012 in the amount of precipitation falling in very heavy events.

Very Heavy Precipitation is defined as the heaviest 1% of all daily events from 1958-2012.

Source: Kenneth Kunkel, Cooperative Institute for Climate and Satellites, North Carolina State University and NOAA NCDC.
Hydrologic Design in Transportation

- All about “Sizing the Structure”
  - Bridges, culverts, pipes
- Design for flow of specified frequency
  - E.g. Q50 - “50-year flow”, “50-year event”
- Calculate flow by regression equations
  - Precip may not even be needed!
- Calculate flow from precipitation by a rainfall - runoff (R/RO) model (urban & smaller watersheds)
  - Assume T-yr rainfall event produces T-yr flow
- Typically assume steady flow hydraulics **
  - Don’t need hyetograph or time series
R/RO Calculators Used in Design

- Rational Method *(intensities)*
  - \( Q = C_i A \)
- TR-20 (NRCS) *(24-hr depth)*
  - Hydrograph method
  - And derivatives
    (ex. HydroCAD, TR-55, parts of HEC-HMS))
- Almost never “calibrated” to real data
- Large, *Unknown* Uncertainties
  - In the precip inputs, the model & model parameters
NOAA Atlas 14

- Standard Source for precip inputs to event-based hydrologic models
  - Also precip.net for the Northeast
- DOT’s have a particular interest in Atlas 14
  - Principal funding partners with NOAA
  - Replaces workhorse 50-yr old TP-40
- Depth-Duration-Frequency (DDF) Curves
  - For TR-20 hydrology
- Intensity-Duration-Frequency (IDF) Curves
  - For Rational Method
PDS-based depth-duration-frequency (DDF) curves
Latitude: 38.0000°, Longitude: -95.0000°

Depth – Duration - Frequency
Intensity – Duration - Frequency
Now and Then – and Tomorrow?

• Atlas 14
  – Looking back
  – historic data (thru 2010 or so)
• Next update probably 20+ years away
• What about tomorrow?
• How to incorporate climate projections in design?
  Should we even try?
Climate Projections?

- Daily time step
  - Design needs (R/RO): sub-daily, even sub-hourly

- Grid Size 10 – 100 km (100 km² – 10,000 km²)
  - Design watersheds (R/RO) 1 ac – 640 ac (0.004 – 2.6 km²)

- Need to **DOWNSCALE**
  - Space
  - Time (disaggregate)

- Climate models not intended for these small space & time scales
What is Needed for Design?

- Projected IDF, DDF curves & tables
  - Use same R/RO design tools
- Focus of ongoing NCHRP research
- Small urban and flashy watersheds likely most at need
  - Strongest relationship bet Rainfall & Runoff
- Larger watersheds?
  - R/RO relationship much more complicated
Wait a Minute!
Step back – take a deep breath

- Don’t just automatically go to design with projections
- Time to look at uncertainty in current IDF / DDF
- Doesn’t come naturally
  – “Give me a number”
- Need a design protocol to look at projections and existing uncertainty

[Table showing average recurrence intervals for different durations]
• We have time to reflect, ponder & act responsibly
• We are *not* facing a crisis when it comes to sizing structures for changing precipitation